



Space Technology Mission Directorate

Game Changing Development Program Update

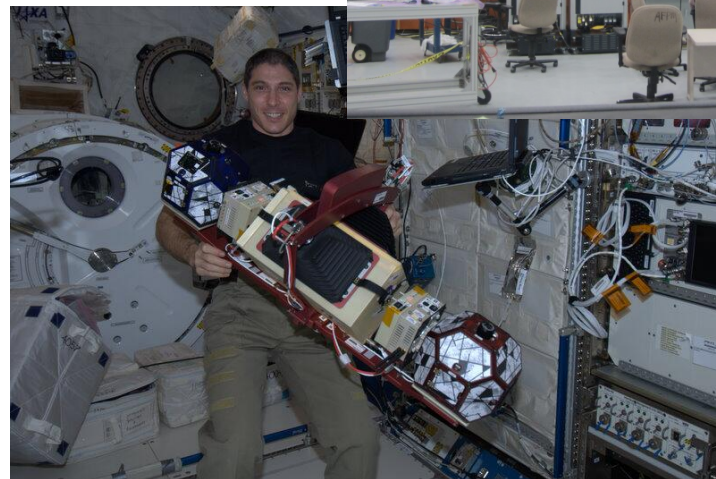
Ryan Stephan
Program Executive, STMD/GCD
29 July 2014



Presentation Outline



- **Space Technology Mission Directorate Overview**
- **Game Changing Development Program Overview & Introduction to Management Themes**
- **GCD's Flagship Project**
- **STMD's Technology Pipeline & GCD's role**
- **Select GCD Content by Programmatic Alignment**
- **Recent Program Accomplishments**
- **Summary**



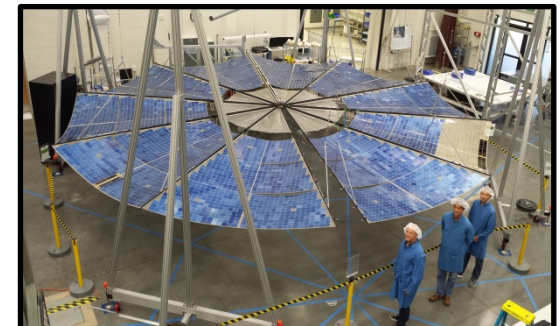
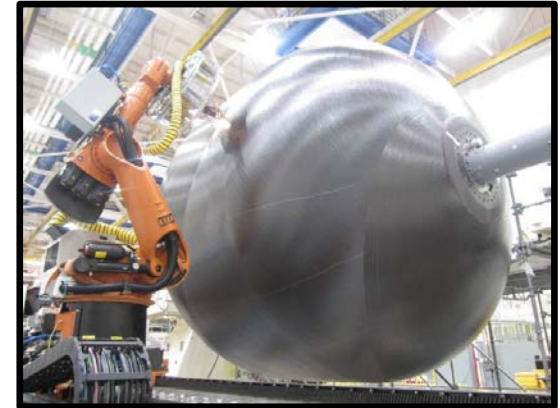


Space Technology

An Investment in Our Future



- Enables a **new class of NASA missions** beyond low Earth Orbit.
- **Delivers innovative solutions** that dramatically improve technological capabilities for NASA and the Nation.
- Develops technologies & capabilities that make NASA's missions **more affordable and reliable**.
- Invests in the economy by **creating markets and spurring innovation** for traditional and emerging aerospace businesses.
- **Engages the brightest American minds** to solve NASA's toughest technological challenges.



Space Technology Portfolio



Transformative & Crosscutting Technology Breakthroughs

Technology Demonstration Missions

bridges the gap between early proof-of-concept tests and the final infusion of cost-effective, revolutionary technologies into successful NASA, government and commercial space missions.



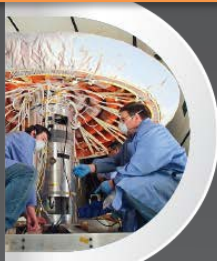
Small Spacecraft Technology Program

develops and demonstrates new capabilities employing the unique features of small spacecraft for science, exploration and space operations.



Game Changing Development

seeks to identify and rapidly mature innovative/high impact capabilities and technologies that may lead to entirely new approaches for the Agency's broad array of future space missions.



Pioneering Concepts/Developing Innovation Community

NASA Innovative Advanced Concepts (NIAC)

nurtures visionary ideas that could transform future NASA missions with the creation of breakthroughs—radically better or entirely new aerospace concepts—while engaging America's innovators and entrepreneurs as partners in the journey.



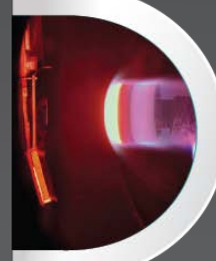
Space Technology Research Grants

seek to accelerate the development of "push" technologies to support the future space science and exploration needs through innovative efforts with high risk/high payoff while developing the next generation of innovators through grants and fellowships.



Center Innovation Fund

stimulates and encourages creativity and innovation within the NASA Centers by addressing the technology needs of the Agency and the Nation. Funds are invested to each NASA Center to support emerging technologies and creative initiatives that leverage Center talent and capabilities.



Creating Markets & Growing Innovation Economy

Centennial Challenges

directly engages nontraditional sources advancing technologies of value to NASA's missions and to the aerospace community. The program offers challenges set up as competitions that award prize money to the individuals or teams that achieve a specified technology challenge.



Flight Opportunities

facilitates the progress of space technologies toward flight readiness status through testing in space-relevant environments. The program fosters development of the commercial reusable suborbital transportation industry.



Small Business Innovation Research (SBIR) and Small Business Technology Transfer (STTR)

Programs provide an opportunity for small, high technology companies and research institutions to develop key technologies addressing the Agency's needs and developing the Nation's innovation economy.



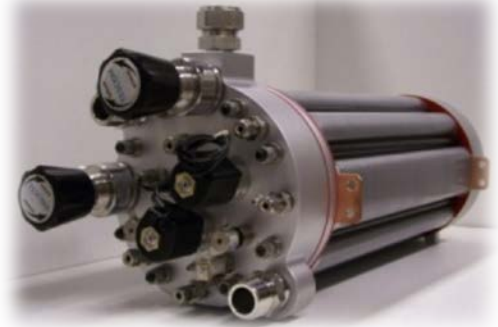


GCD Program Vision & Management Themes



Game Changing Vision:

- Enable NASA's exploration missions by rapidly advancing disruptive mid-TRL technologies from concept to demonstration
 - Technology incubator for STMD & the Agency
- Program organized into five themes



Future Propulsion & Energy Systems (FPES)



Affordable Destination Systems & Instruments (ADSI)



Advanced Entry, Descent, & Landing (AEDL)



Lightweight Materials & Advanced Manufacturing (LMAM)



Revolutionary Robotics & Autonomous Systems (RRAS)



Select GCD Activities By Management Theme

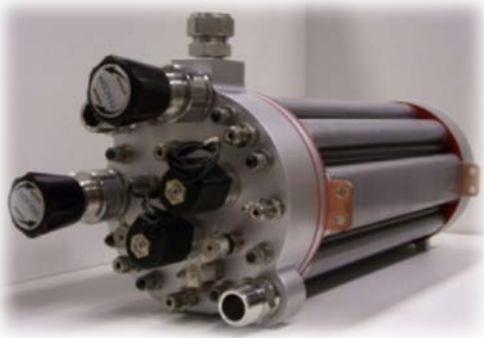


Affordable Destination Systems & Instruments



- Spacecraft oxygen recovery
- In situ production of oxygen
- High performance computing
- Optical communications
- High performance thermal control

Future Propulsion & Energy Systems



- Fission-based power production
- High capacity batteries
- Micro-fluidic electro-spray propulsion

Lightweight Materials & Advanced Manufacturing



- Composite cryotank
- Nanotechnology
- Additive manufacturing

Advanced Entry, Descent, & Landing



- Thermal Protection System Materials
- Supersonic retro propulsion
- Inflatable/deployable entry systems

Revolutionary Robotics & Autonomous Systems



- Crew-assisting robots
- Habitat automation
- Extreme terrain mobility

*GCD Activities
Span 8 STMD
Thrust Areas*

GCD's Flagship Project: Composite Cryotank Technologies & Demonstration (CCTD)



- The Problem:
 - NASA requires an affordable, lightweight vehicle to enable future exploration
- The Solution:
 - Design, fabricate, & test an affordable, low mass composite cryotank
- The Accomplishments:
 - Designed & fabricated a 5.5m diameter composite cryotank
 - Developed using automated manufacturing techniques & out-of-autoclave materials/cure
 - Demonstrated 30% (~3,300 lb) mass savings & 25% cost reduction (~\$7M)¹
- Development Milestones:
 - Tank delivered from Boeing to MSFC on 26 March 2014
 - 45 psi ambient pressure test was performed on 22 May 2014
 - Analytical models updated/correlated
 - Cryogenic pressure test was performed at ~60 psi on 20 July 2014
 - Will perform 80 cryogenic pressure cycles & mechanical loads/pressure test

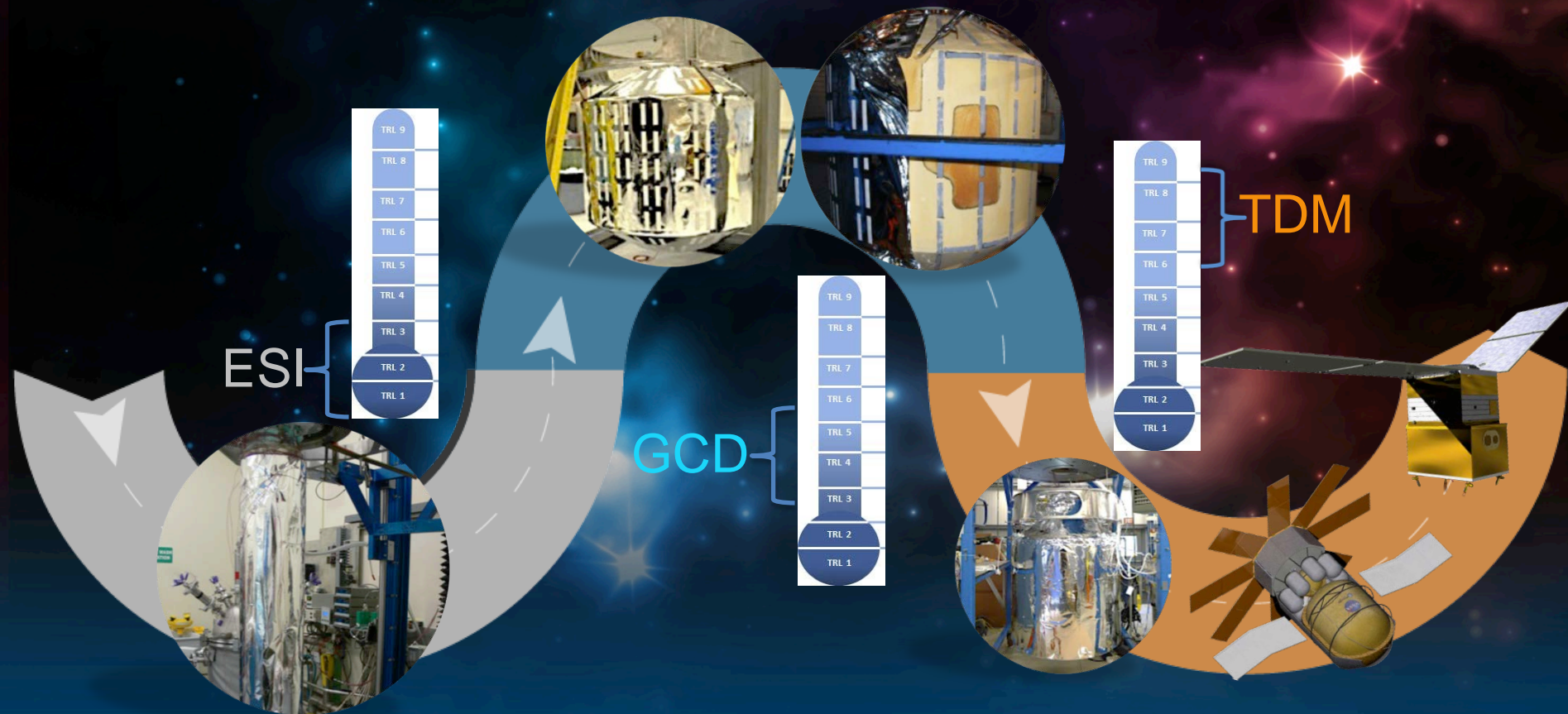




Space Technology Pipeline



Mature low TRL technologies from CIF, STRG, & SBIR towards mission infusion



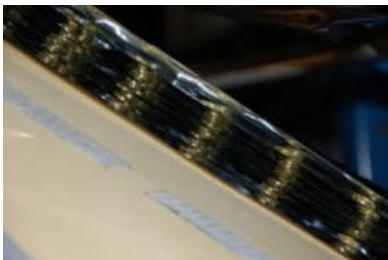
TECHNOLOGY PIPELINE



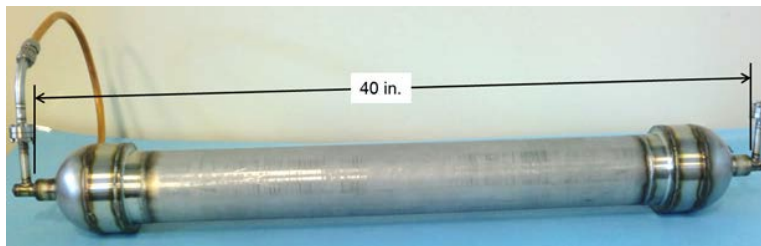
Examples of SBIR Success Stories



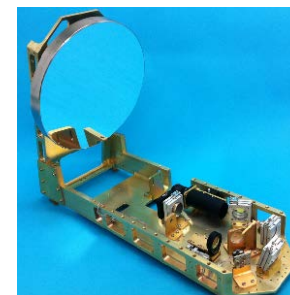
Technology	Maturation Path	Infusion
Self Supporting Multi Layer Insulation	<ul style="list-style-type: none"> Discovered as Phase I SBIR. Continued technology maturation as Phase II SBIR. Using NASA-owned research hardware, GCD matured the technology to TRL 5 as Phase III SBIR. 	<ul style="list-style-type: none"> Will be infused into TDM's Green Propellant Infusion Mission (GPIM) project. Performance will be demonstrated as part of TDM's eCRYO project. Potential for further infusion into SLS.
20 Watt, 20 Kelvin Cryocooler	<ul style="list-style-type: none"> Component technologies matured as Phase I & Phase II SBIRs. Additional risk mitigation effort performed as Phase II-E & Phase III SBIR. If risk mitigation activity is successfully executed, cryocooler will be developed using a Phase III SBIR. 	<ul style="list-style-type: none"> Performance will be demonstrated as part of TDM's eCRYO ground demonstration project. Potential for further infusion into SLS.
Deep Space Optical Communication	<ul style="list-style-type: none"> Deep-space photon-counting camera matured as Phase II SBIR. Spacecraft disturbance isolation assembly being developed as part of Phase II SBIR activity. Deep-space laser transmitter being developed as part of Phase III SBIR effort. 	<ul style="list-style-type: none"> STMD will mature & provide deep space optical communication flight hardware as Government Furnished Equipment for potential demonstration on SMD's Discovery 2014 mission.



Edge-On View of Self Supporting MLI



Cryocooler Recuperative Heat Exchanger



DSOC Optical Transceiver Assembly



Examples of SBIR Success Stories Continued



Technology

Maturation Path

Infusion

3D Print

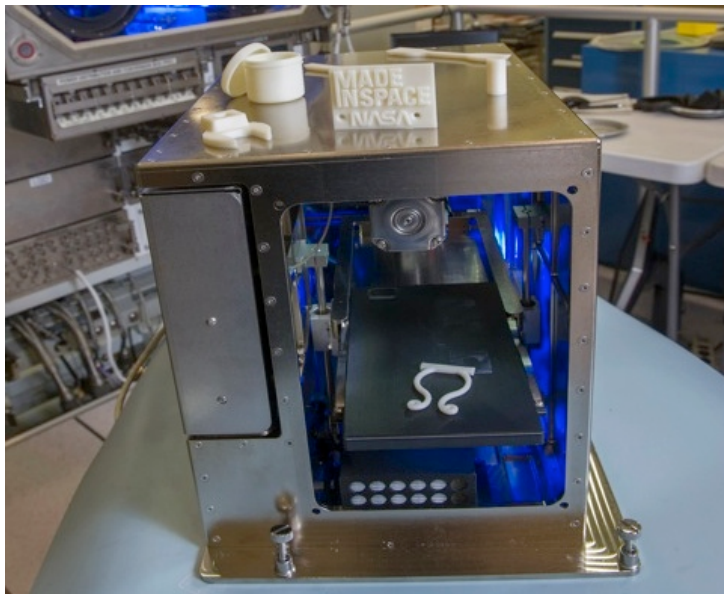
- Phase I SBIR was used to complete a feasibility & trade study for a microgravity 3D Printer.
- Phase III SBIR was used to design, fabricate, & test a 3D Printer for demonstration on ISS.

- Flight hardware will be delivered on SpaceX-4 & demonstrated on ISS.

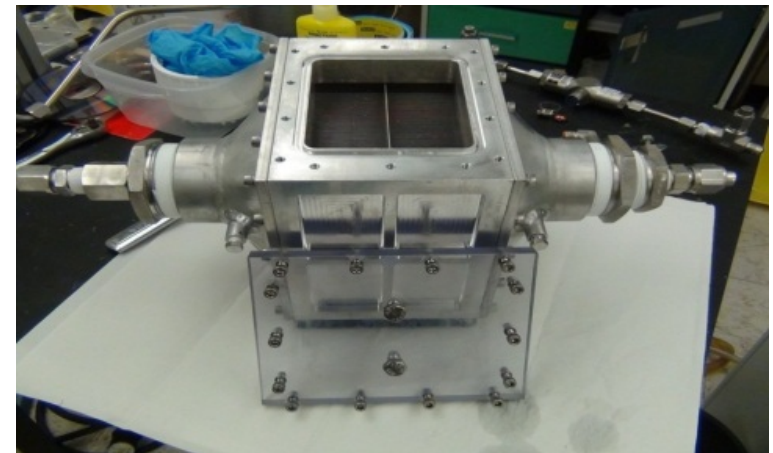
Phase Change Material Heat Exchanger

- Proof-of-concept heat exchanger developed as part of Phase I SBIR.
- Proof-of-concept heat exchanger performance subsequently verified at JSC.
- Phase III SBIR awarded to develop prototype heat exchanger.

- If successfully demonstrated on ISS, heat exchanger will be infused into Orion's thermal control system for Lunar missions.



3D Printer Flight Hardware



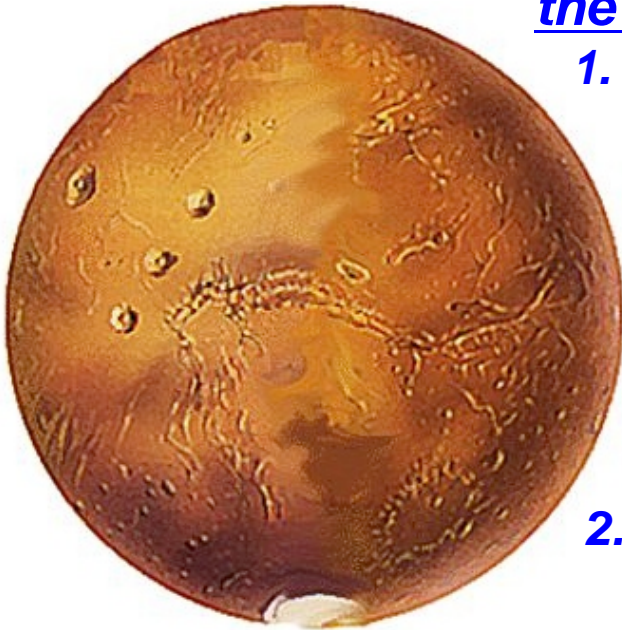
Water-Based Phase Change Material Heat Exchanger



Select GCD Projects By Programmatic Alignment (Mars 2020)



STMD Will Develop Two Payloads for Infusion into the Mars 2020 Mission:



1. *In Situ Resource Utilization (ISRU) Demonstration*
 - *Competitively selected technology demonstration to convert Mars' atmosphere into valuable oxygen (fuel & life support)*
 - *Benefits both robotic & human exploration:*
 - *Reduced Earth-launch mass & mission cryogenic storage burden*
 - *Reduced burden on EDL systems*
2. *Mars Entry, Descent, and Landing (EDL) Instrument (MEDLI-2)*
 - *Developing sophisticated instrumentation suite to acquire critical EDL data benefiting future exploration missions*
 - *Instrument both heat shield AND backshell*
 - *Benefits Include:*
 - *Valuable flight data to validate analytical models (Reduced TPS design margins)*
 - *Data necessary to reconstruct planetary entry*



Select GCD Projects By Programmatic Alignment (ISS)¹



STMD Leverages, and Partners With, the Valuable On-Orbit National Asset:

1. SPHERES SLOSH Experiment

- KSC, FIT, & MIT partnered to develop demonstration hardware for ISS
- Hardware delivered to ISS in January 2014
- Three experimental sessions completed subsequent to hardware delivery
- Performed microgravity experiments to obtain slosh data for model correlation/validation

2. Phase Change Material (PCM) Heat Exchanger

- Develop & demonstrate 2 PCM heat exchangers
- Will retire risks associated with microgravity operation of large-scale PCM heat exchanger for infusion into Orion TCS

3. Station Explorer for X-Ray Timing & Navigation Technology (SEXTANT)

- Partnering with NICER project (SMD) to demonstrate advanced, autonomous navigation technology using Pulsars as beacons



¹List does NOT include all planned ISS demos



Select GCD Projects By Programmatic Alignment (Orion & SLS)

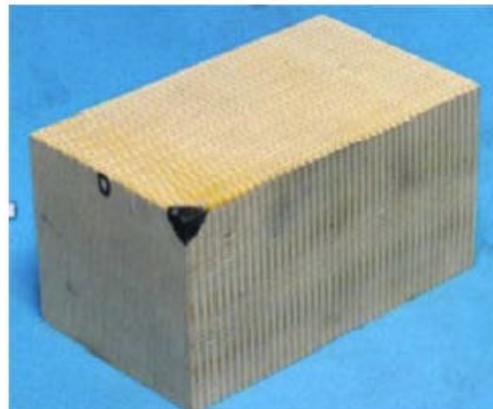


STMD is Developing Critical Technologies to Enable Orion & SLS Exploration:

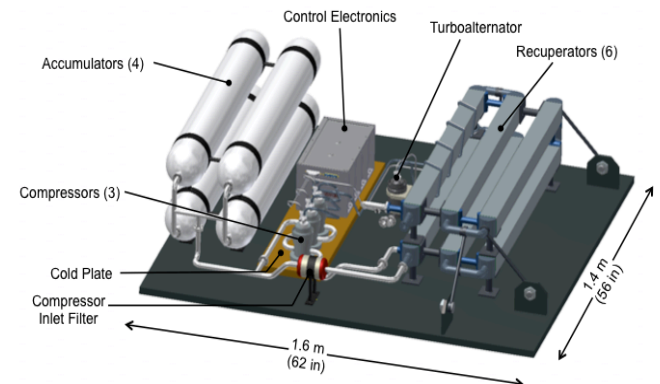
1. **3D Multifunctional Ablative TPS (3D MAT)**
 - **Maturing woven TPS for infusion into Orion**
 - **Compression pad is required to meet severe structural and thermal loading**
2. **Composite Cryotank**
 - **Fabricated & currently testing 5.5m diameter composite cryotank**
3. **20 Watt, 20 Kelvin Cryocooler**
 - **Develop high capacity cryocooler to enable zero boil-off of liquid hydrogen**



5.5m diameter composite cryotank



3D MAT TPS Billet



Turbo-Brayton Flight Cryocooler Concept



Select GCD Projects By Programmatic Alignment (SMD/Discovery)



STMD is Maturing Revolutionary Technologies for Discovery 2014¹:

- *Technologies were highlighted during April Technology Workshop*
- *Technologies included in July's draft AO*
- *MOU signed to mature two technologies to TRL 6 by the end of FY 2017*

1. Heat Shield for Extreme Entry Environment Technology (HEEET)

- *Low mass (40%), high performance TPS material for planetary entry missions*
- *SMD will provide \$10M incentive*

2. Deep Space Optical Communication

- *Communication technology providing order of magnitude higher data rates for deep space exploration*
- *STMD will GFE flight hardware*
- *SMD will provide \$30M incentive*

¹List does not include additional technologies being matured by TDM (ASA, GPIM, & DSAC)



Recent Program Accomplishments



- Delivered two RPM prototype instruments to AES
- Delivered & integrated two EVA components into AES's PLSS 2.0 testbed
- Delivered nuclear reactor simulator
- Completed fabrication & integration of two Stirling power conversion units
- Selected 4 performers for energy storage
- Completed HEEET Arc Jet testing
- Completed long-term creep test with Vectran (webbing material for inflatable structure) and delivered results to AES/BEAM
- Completed continuation review for 10 on-going National Robotics Initiative grants
- Delivered R2 legs to ISS on SpaceX-3



NS – Power Conversion Unit



Long term creep testing with webbing straps



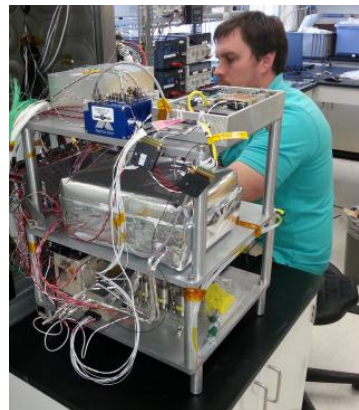
ISRU – Neutron Spectrometer



NGLS – Variable Oxygen Regulator



NGLS – Rapid Cycle Amine



ISRU – LAVA



R2 Engineering Development Unit Legs





Summary



- *GCD is rapidly maturing critical technologies to enable future exploration missions*
- *GCD's investments span all eight STMD thrust areas*
- *GCD enables the space technology pipeline*
- *GCD's technology investments are well-aligned with top agency priorities*

